

HOME WATER SAVINGS PROJECT

John Olaf Nelson

General Manager, North Mann Water District, Novato, California
Chair, American Water Works Association, Water Conservation Committee

Project Description

To determine the cost-effectiveness of a water conservation audit targeting single family detached homes and including actual installation of devices and toilet leak repairs, in May of 1988, the North Marin Water District invited randomly selected water users in the single family detached home residential classification to make an appointment for a free home water audit. Two hundred and thirty-seven audits resulted from 1,276 offer letters mailed, a participation rate of 18.6%. The audits were conducted during the period June 7, 1988 through August 5, 1988.

A college student, intensively trained over a three day period and supplied with easy look-up reference material performed the audits. Appointments were made with respondents and audits were scheduled at one hour and forty-five minute intervals. Approximately thirty minutes of this time was devoted to collecting research information and fifteen minutes was for travel. The auditor ordered and prepared all his materials. Office personnel made most of the appointments. Including this support labor, training time and down time, the total time per audit was two hours and thirty minutes.

Arriving at the site, the auditor performed the following activities:

- 1) Checked water meter dial for movement to detect leaks.
- 2) Met homeowner and obtained answers to research questions and explained what he would be doing.
- 3) Measured the "full open" flow rate of each shower and installed 2.7 gallon per minute (gpm) shower heads with trickle shut-off valves if the measured flow rate was greater than 3.0 gpm.
- 4) Tested each toilet for leaks using a dye tablet and performed simple repairs (float/linkage adjustment and/or flapper valve replacement) if a leak was detected.
- 5) Inserted one or two one-quart plastic displacement bottles weighted with gravel in each toilet tank and checked for a satisfactory flush.
- 6) Visually checked for leaks both inside and outside the house.
- 7) if lawns were present, probed soil under "best lawn" to determine general soil type and infiltration characteristics and noted any thatch or compaction problems.
- 8) Measured precipitation rate of the water system or hose and sprinkler serving the "best lawn" and determined the lower quartile uniformity coefficient.
- 9) Using evapotranspiration data and turf crop coefficients developed for the Novato area, calculated a spring, summer and fall irrigation schedule for lawn areas.
- 10) Took measurements of landscape area and made observations and collected extensive information.
- 11) Filled out and then presented occupant with "A Special Water Conservation Report";

information on ways to save water, and some free gifts including a soil moisture meter and a rebate letter for a starter drip irrigation kit having a retail value of \$16.00 (20% of the audited homes redeemed the rebate at participating area hardware stores). The kit cost the District only \$8.00 as retailers donated half the value.

Materials

The shower heads selected for installation provided the following features:

- 1) Yielded a wet droplet type spray in order to reduce body heat loss (compared to fine aeration type heads) hence believed to require less energy.
- 2) Was relatively large in size thus “separating” itself from the small aeration type head to which some people automatically react as requiring a sacrifice.
- 3) Although made of plastic, the shower head was chrome plated and was ruggedly constructed.
- 4) Easily adjustable spray pattern.

The shower heads were fitted with a chrome plated brass shut-off valve which trickled water in the off position to lessen the chance of scalding when flipped back on.

Weighted one-quart displacement bottles were selected for the toilet insert. The District’s test experience, albeit informal, has been unimpressive regarding use of toilet dams. The bottles can easily be inserted (at least one) in most toilets without interfering with the flush mechanism. They have the general size and shape of a one-quart oil container. The tops are sliced off and they are weighted with 2 inches of washed river gravel. Two bottles can be installed in most five gallon flush toilets.

The homeowner was also provided the fol-

lowing informational materials:

"Puddle Stoppers Handbook" (East Bay Municipal Water District)

“How Much Water Does Your Lawn Really Need?” (Sunset Magazine reprint)

“Water Saving Planting Ideas” (Sunset Magazine reprint)

“How to Read Your Water Meter” (North Marin Water District)

“40 Ways to Save Water” (Smith)

12-inch ruler promoting conservation
Sonoma County Water Agency)

Stickers (Sonoma County Water Agency)

Bumper sticker
(Sonoma County Water Agency)

Xeriscape brochure with plant list
(North Marin Water District)

Extra dye tabs for subsequent toilet leak checks
(4)

Moisture meter gift

Rebate letter for drip starter kit

Cost

The pilot project was expected to cost \$47.50 per home. Actual cost was \$55.12 per home audited. These costs include the promotion costs necessary to reach the audited homes. Cost of the auditor, including payroll additives was \$10 per hour. A breakdown of the costs incurred is shown in Table 1.

Total audit time (portal to portal including “down” time) was 2.5 hours per dwelling audited.

**TABLE 1.
COST OF HOME AUDIT**

	Unit	Total	Cost/Audit ¹
Materials			
shower heads w/trickle shutoff	\$3.25	\$ 764	
shower head adaptors	0.92	116	
displacement bottles	0.34	290	
dye tablets	0.12	68	
flapper valves (for toilet repairs)	3.28	272	
mailers and handouts	varied	1,230	
promo gifts	varied	1,227	
misc other hardware	varies	<u>56</u>	
		\$4,023	\$16.98
Labor and Other:			
auditor	\$10/hr	5,938 ²	
support personnel	Varied	1,627 ²	
transportation	\$0.50/mi	474	
training		<u>1,000</u>	
		9,039	\$38.14
TOTAL		<u><u>\$13,062</u></u>	<u><u>\$55.12</u></u>

¹237 Audits

²Includes payroll additives and overhead

This could be reduced by one-half hour or \$5.00 if the extensive data compiled in this pilot study was not collected. If, in addition, the gifts (moisture meter and irrigation kit rebate) were eliminated, the audit cost could be reduced by another \$5.19. Total feasible cost reductions, therefore, are estimated to yield a "least cost" audit price of \$44.93, say \$45 per home audit performed.

Penetration

The average number of showers and toilets per home and "pre-", "post" and "net" increase in penetration (in terms of devices installed per fixture) was:

	Fixtures	Pre-Audit Pene.	Post-Audit Pene.	Net increase in Pene.
shower heads	1.96/home	30%	91%	61%
toilets bottles	2.40/home	11%	100%	91%

The average density of toilet displacement bottles (one-quart) before the audit was 0.16 bottles/toilet. This was increased to 1.50 bottles/toilet. The latter value is believed to be the theoretical maximum for the audited homes because 41% of the toilets were 3.5 gal/flush models. The auditor attempted bottle insertion (2 per toilet) in every toilet and backed down to one or none if he judged flush performance to be unsatisfactory.

Periodic post penetration surveys are planned to determine the retention rate over time for the devices installed.

Water Savings and Payback

Water costs 95c/1000 gallons (71 c/ccf, 1 ccf= 748 gallons) in the North Marin Water District service area (uniform commodity rate). Going into the audit project, water savings of 13,875 gallons per

year was hypothesized for the average participating home (6,675 gallons inside and 7,200 gallons outside). Average water use for the audited users was measured and averaged 200,913 gallons/year (269 ccf/yr) so the expected savings of 13,875 gallons per year represented a reduction of 6.9%. Projected annual monetary savings, including hot water savings of \$10.80, was estimated at \$23.96 per participating home per year. Simple payback from the homeowner's perspective, based on original cost estimates for conducting the project was therefore estimated to be \$47.50/23.96 = 2.0 years.

Actual observed water savings (based on comparing water use in the first full water year (October 1 - September 30) following the audits, to the average use experienced in the four water years prior to the audits) was 9,188 gallons per year or 4.6%. Of this amount, "inside" savings based on the number of devices installed, toilet leak repair and given pre-audit shower head penetration of 30% and toilet bottle penetration of 11% (based on saturation penetration of 1.5 one-quart bottles per typical toilet), was calculated to be 7,270 gallons per year. The balance or 1,918 gallons per year was attributed to "outside" savings and was well below the hypothesized outside savings of 7,200 gallons per year. Participating homes reported a mean household density of 2.96 persons. Detailed water savings results are shown in Table 2.

Actual dollar savings experienced by the homeowner is calculated at \$22.62 per year and includes hot water savings of \$13.90 per year. Actual simple payback based on the actual cost of the audit was 2.4 years. Details of this calculation are shown in Table 3.

Home Water Use Characteristics

From the multitude of information collected for the audited homes showing how water is used, some interesting highlights observed were:

Inside: Homes having 3.5 gal/flush toilets - 40%; the number of homes installed after 1979 .41% (the 3.5 gal/fl standard became law in California for

new construction commencing Jan. 1978); "most used" bathroom . master, bathrooms/home . 2.40; showers/home . 1.96; % of existing low flow (less than 3 gpm) shower heads . 30%; low flow heads added . 61%; percent of shower heads added needing adaptor . 27%; leaking toilets . 18%; leaking toilets easily repaired by auditor .81%; most common repair .replace flapper valve.

Outside: Homes with lawns -9.5%; average lawn area for homes with lawns . 1,494 sq ft; average total landscaped area for all homes in sample 3,221 sq ft; appearance (1 to 10 scale) . 7; lawns irrigated with inground system . 62%; systems having controller .58%; hoses controlled by timers . 7%; average precipitation rate (all systems) .1.4 inches/hour; lower quartile uniformity coefficient . 0.42.

Statistical Analysis and Validity Checks

After the survey work was completed, the 237 audited homes were sorted by address and a "vicinity" established for each home that was audited. A "control" home was selected randomly from each vicinity or microclimate to establish a parallel control group which could be compared against the sample group consisting of the audited homes. The control homes may or may not have received an offer notice, however none requested or received an audit. The odds of a control home receiving an offer notice was about 1:15 since the District limited its offers to accomplish requests for no more than 240 audits. This was felt to be a sufficient sample for analysis.

Next, historic water use going back to October 1983 was determined for each home in the control group and sample group. Each record was plotted and visually inspected to determine if the record was incomplete or if an obvious leak had occurred which would skew the record. The result of this screening was to reduce the sample to 169 homes and the control to 157 homes. For both groups, the reason for rejecting a record was about evenly distributed between "incomplete" vs. "major leak". Average annual use for each account was

**TABLE 2.
WATER SAVINGS**

Total Water Saved Per Home (from statistical analysis)		9,188 g/yr (8.5 gpcd)
Portion calculated as being saved "inside"		
toilet flushing		
1.34 gpcd x 2.96 x 365	1,448 g/yr	
toilet leak repair		
20 g/d x 365 x 18% x 81%	1,077	
shower water use		
7.2 gpcpd x 2.96 x 365 x 61%	<u>4,745</u>	
		7,270 g/yr (6.7 gpcd)
Portion calculated saved "outside"		
9,188 - 7,270		1,918 g/yr (1.8 gpcd)
Measurements/Assumptions		
• occupancy per dwelling	2.96 persons	
• number of single family dwellings audited	237 d.u.	
• average reduction in per capita flush requirement 4 fl pcd x 1.34 bottles x 0.25 g/bottle	1.34 gpcd	
(based on addition of 1.34 bottles to average toilet in sample)		
• assumed average toilet leak rate	20 gpd ¹	
• toilets found to have leak as percentage of all toilets	18%	
• leaking toilets that were repaired	81%	
• shower water savings from installing low-flow (2.7 gpm) shower heads	7.2 gpcpd ²	
• portion of sample showers retrofitted with 2.7 gpm shower heads	61%	
Total Water Use Per Audited Home Before the Audit³		200,913 g/yr
% Reduction		4.57 %

¹ Assumption by author

² U.S. Department of Housing and Urban Development Summary Report on Residential Water Consumption Projects, June 1984.

³ Average for Four Water Years (1984 - 1987).

then determined for the four water years preceding the audit for each group and the data was tested to see if it was normally distributed using the Chi-Square test. Both groups showed normal distribution indicating that standard statistical comparisons could be made. Standard parametric analysis techniques were then followed and the mean difference of 4.6% was calculated with a 95% confidence level.

Recap

The pilot project tested the hypothesis that a home water audit program involving installation

of devices, toilet leak repairs and irrigation scheduling advice would yield water savings of 6.9% with a simple payback (customer's viewpoint) of 2.0 years. The results to date indicate actual savings of 4.6% with a confidence level of 95% and a simple payback of 2.4 years. Savings achieved inside the home were calculated to be within 10% of hypothesized inside savings; savings outside, however, fell far short and were calculated to be 27% of hypothesized outside savings, suggesting that a more effective strategy needs to be developed targeting outside single family home water use.

TABLE 3.
COST OF WATER SERVED AND SIMPLE PAYBACK

Cost per average home audited: **\$55.12**

Annual savings enjoyed by average home audited:

toilet displacement bottles 1448 g/yr x \$0.9491/1000 g	\$1.37/yr
toilet leaks repaired 1077 g/yr x \$0.9491/1000 g	1.02
low-flow shower heads installed 4745 g/yr x \$0.9491/1000 g	4.50
irrigation water saved 1918 g/yr x \$0.9491/1000 g	<u>1.83</u>
Total cost of water saved	\$8.72/yr
shower energy cost savings \$7.70 pcpyr x 2.96 x 61%	\$13.90/yr
Total annual savings	\$22.62/yr

Simple Payback Period

First costs/annual savings:
\$55.12 \$22.62 \$2.4 yrs

¹ U.S. Department of Housing and Urban Development Summary Report on Residential Water Conservation Projects, June 1984.